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Report on the networking activities

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[1]

LIST OF ACRONYMS AND ABBREVIATIONS

ATOMKI	Magyar Tudományos Akadémia Atommagkutató Intézet
CERN	Conseil Européen pour la Recherche Nucléaire
ECR	Electron Cyclotron Resonance
GANIL	Grand Accélérateur National d'Ions Lourds
GSI	Gesellschaft für Schwerionenforschung
JYFL	Jyväskylän Yliopiston Fysiikan Laitos (Department of Physics, University of Jyväskylä)
KVI-CART	Kernfysisch Versneller Instituut-Centre for Advanced Radiation Technology
LPSC	Laboratoire de Physique Subatomique et de Cosmologie
OES	Optical Emission Spectroscopy
UCLM	Universidad de Castilla-La Mancha
MIDAS	MInimisation of Destructive pLASma processes in ECRIS

EXECUTIVE SUMMARY

This deliverable report describes the main achievements of the MIDAS Networking Activity (NA). The activity consists of teams developing Electron Cyclotron Resonance Ion Sources (ECRIS) and beams for the needs of the ENSAR2 facilities. The participating teams are ATOMKI, CERN, GANIL, GSI, JYFL, KVI-CART, LPSC and UCLM. In addition, the networking includes two industrial partners: AVS and PANTECHNIK. The networking has mainly been carried out through annual collaboration meetings, hands-on-trainings and developing and maintaining a common database, including a vast amount of information needed in day-to-day ion beam production and operation of ECR ion sources.

INTRODUCTION

The objective of the MIDAS-NA was to enhance the networking between partner teams in order to further improve the ion beams in terms of their intensity, energy, quality and variety in the most effective way. The networking has mainly been carried out via annual workshops and hands-on training sessions. The objective of the hands-on training was to promote the transfer of the optimised and the most useful methods between the participating institutes. This improves not only the expertise of the staff but day-to-day operation of facilities as well. The annual meetings offered a relaxed environment for open and fruitful discussion between the experts of the participating institutes. New practices, information and closer networking are expected to enhance the operation of ENSAR2 facilities. The workshops and trainings offered also an opportunity to plan common experiments and to exchange different instruments between the MIDAS partners. This has and will allow MIDAS teams to perform new and more complicated experiments and as a result, the networking carries significant potential for new developments and discoveries in ion source physics and technology. The advancement in ion source technology will further advance the research possibilities of the European nuclear physics community. A common database has been developed to spread best practices and to include up-to-date information needed for the efficient operation of the ENSAR2 facilities.

SECTION 1 TASKS OF MIDAS NETWORKING ACTIVITY, ACHIEVED RESULTS AND PROGRESS

The MIDAS-NA was divided to three separate tasks as follows:

Task 1: Coordination of scientific activities and dissemination.

Task 2: Collaboration workshops to present the most important results and to promote open discussion.

Task 3: *Hands-on training* to promote the transfer of most useful methods and practices.

Task 1: The Steering Committee (SC) of MIDAS-NA coordinated and organized the activity to advance the networking and dissemination of good practices and know-how between the partner laboratories. The main tools to achieve the goals were annual workshops (Task 2), hands-on training (Task 3) and website including all relevant information for the use of partner teams. Tasks 2 and 3 are presented later in this deliverable report. As the first action, the steering committee was formed and reported as the first milestone ("MS3.1-MIDAS). The following steering committee members were selected: Hannu Koivisto (coordinator/JYFL), Pascal Jardin (deputy-coordinator/GANIL), Klaus Tinschert (member/GSI) and Sandor Biri (member/ATOMKI). The website to include the common database to serve the MIDAS community was established and the data input was started. As an example, the beam database includes instructions to prepare different ion beams with the ECR ion sources. The reports for this subtask were completed in accordance with the original plans (MS3.2-MIDAS and D3.1-MIDAS). In addition to the beam database, the website includes all documents regarding tasks 2 and 3. The MIDAS website can be found using the following link:

<https://wiki.jyu.fi/display/ensar2/Website+for+European+collaboration+on+ECR+ion+sources%2C+MIDAS-NA>

and is accessible also via the official website of ENSAR2 consortium by clicking the MIDAS link:

<http://www.ensarfp7.eu/activities/networking-activities>.

Task 2: *Collaboration workshops: (deliverable report D3.3-MIDAS)*:

The main objectives of the annual workshops were to present the most important results of the participating teams, to present new requirements set by the infrastructures of partner institutes regarding the research and development of ECR ion sources and their beams and to allow a platform for open discussion and problem solving. The workshops offered also an opportunity to optimise different research resources to make new and more advanced research and development possible. Some examples are given in Section 2.

The overall information of the workshops is shown in Table 1. The duration of each workshop was 2 days and they were organised in accordance with the original plan. The first day of the meeting focussed on the status reports and the second day on the collaboration planning and open discussion about the scientific problems and challenges. The first and the second annual workshop emphasised the organisation and the follow-up of the MIDAS Networking Activity. The third and the fourth workshops emphasised the developed networking and the planning of the future collaboration. The industrial partners attended in the meetings and participated in the discussions and problem solving.

All workshop presentations, agendas, minutes and other related documents can be found from the MIDAS website using the following links:

- 1) MIDAS kick-off-meeting (21-22.6.2016, hosted by JYFL):
<https://wiki.jyu.fi/display/ensar2/MIDAS+kick+off+meeting+2016>
- 2) Second Annual MIDAS Meeting (30-31.5.2017, hosted by KVI-CART):
<https://wiki.jyu.fi/display/ensar2/Annual+meeting+2017>
- 3) Third Annual MIDAS Meeting (23-24.5.2018, hosted by UCLM):
<https://wiki.jyu.fi/display/ensar2/Annual+meeting+2018>
- 4) Fourth Annual MIDAS Meeting (26-27.6.2019, hosted by GANIL):
<https://wiki.jyu.fi/display/ensar2/Annual+Meeting+2019>

Table 1: *Annual Workshops organised during the MIDAS Networking Activity.*

Name of Workshop	Host lab	Location	Dates	Participants	Presentations	Agenda/ Minutes
MIDAS Kick-off-Meeting	JYFL	Jyväskylä, Finland	21-22.6.2016	14	available	available
Second Annual MIDAS Meeting	KVI-CART	Groningen, Netherlands	30-31.5.2017	20	available	available
Third Annual MIDAS Meeting	UCLM	Toledo, Spain	23-24.5.2018	13	available	available
Fourth Annual MIDAS Meeting	GANIL	Caen, France	26-27.6.2019	17	available	available

Task 3: *Hands-on training (deliverable report D3.4-MIDAS)*: The objective of the hands-on training was to promote the transfer of the optimised and the most useful practices between the participating institutes. This makes possible to improve not only the expertise of the staff but day-to-day operation of each facility as well. The most important hands-on training subjects were defined among the partners, program for each training was prepared and then reported (MS3.3-MIDAS). The trainings and the organising institutes are listed in the following:

- Low-temperature plasma diagnostics (UCLM)
- ECR charge-breeder techniques (LPSC)
- Low-energy beam-transport design and emittance measurements (KVI-CART)
- MIVOC method and/or Highly charged plasma diagnostics (JYFL)

- Microwave-based techniques to improve the performances of the ECRISs (GSI)
- Iron-beam production with ECR4 ion source using oven technique (GANIL)
- Measurements of ECR plasma parameters by Langmuir-probe (ATOMKI)
- Nickel-beam production with the CAPRICE ECRIS using the GSI standard oven (GSI)

As a result of the hands-on training program, 15 training sessions were organized and 61 participants were trained. The training program is shown in Table 1 and the complete information on the training programmes, schedules and reports can be found on the MIDAS-website:

<https://wiki.jyu.fi/display/ensar2/Hands-on-training>.

Table 1: The overall schedule of the hands-on training.

Title of hands-on-training	Course #	Host lab	Start date	Duration	Participants	Status	Report
Metal-beam production with Phoenix V2 ion source	1	GANIL	15 Nov 2016	3 days	5 (+1)	accomplished	available
MIVOC Method	1	JYFL	5 Dec 2016	2.5 days	3	accomplished	available
Highly Charged Plasma Diagnostics	1	JYFL	5 Dec 2016	2.5 days	5	accomplished	available
MIVOC Method	2	JYFL	7 Dec 2016	2.5 days	4	accomplished	available
Highly Charged Plasma Diagnostics	2	JYFL	7 Dec 2016	2.5 days	3	accomplished	available
Measurements of ECR plasma parameters by Langmuir-probe	1	ATOMKI	10 May 2017	2 days	4	accomplished	available
Microwave-based techniques to improve the performances of the ECRISs	1	GSI	12 Dec 2017	3 days	4	accomplished	available
ECR Charge breeder techniques and low temperature oven	1	LPSC	23 Jan 2018	3 days	4	accomplished	available
Microwave-based techniques to improve the performances of the ECRISs	2	GSI	27 Feb 2018	3 days	4	accomplished	available
Nickel-beam production using the oven technique with CAPRICE ECRIS	1	GSI	13 Mar 2018	3 days	5	accomplished	available
Measurements of ECR plasma parameters by Langmuir-probe	2	ATOMKI	20 Jun 2018	2 days	4	accomplished	available
Low-temperature plasma diagnostics	1	UCLM	25 Sep 2018	3 days	5	accomplished	available
Low-energy beam-transport design and emittance measurements	1	KVI-CART	9 Oct 2018	3 days	4	accomplished	available
Low-energy beam-transport design and emittance measurements	2	KVI-CART	16 Oct 2018	3 days	4	accomplished	available
Low-temperature plasma diagnostics	2	UCLM	4 Dec 2018	3 days	4	accomplished	available

SECTION 2 NEW AND PLANNED ACTIVITIES ORIGINATING FROM OR ENHANCED BY THE MIDAS NETWORKING ACTIVITY

The MIDAS hand-on training and annual workshops have stimulated numerous discussions about global and detailed techniques, and reinforced human connections between laboratories, which is essential to open and fruitful exchanges. The following list shows existing collaborations that have been strengthened and new collaborations that have been initiated as a result of the MIDAS-NA:

- JYFL-LPSC: The JYFL-LPSC plasma instability collaboration has been started under the EMERGENCE project. The visible light spectrometer, developed during MIDAS-NA at JYFL for highly charged ECRIS plasma studies, will be used in future studies of EMERGENCE collaboration. Pooling of devices: high-resolution spectrometer, different kinds of microwave components and devices.
- JYFL-GANIL (+ LPSC): New collaboration between GANIL and JYFL is organized in the framework of the charge breeder studies and, especially, on the topic of the ion confinement time. At GANIL, this value is of great importance concerning the Radioactive Ion Beam production particularly for the short half-life element. Pooling of devices: current amplifiers and equipment for data acquisition.
- The MIVOC method developed at JYFL still offers interesting prospects. Its principle based on the use of molecules with high vapour pressure can be applied to inject various elements into ECRIS plasma, even refractory ones that often present technical challenges with other methods. Thanks to close exchanges made possible within the MIDAS hands-on-training program, the MIVOC is still under improvement at GANIL to extend the variety of its ion beams catalogue.
- JYFL-GSI: collaboration to build a copy of JYFL-HIISI ECRIS for FAIR and further develop it at GSI.
- UCLM-GANIL: Thermal simulations have been performed in UCLM-GANIL collaboration to improve the design of the current high temperature oven used at GANIL, and to avoid condensation of metal on cold parts of the oven. Results have led to a modification of the design and the upgraded oven will be shortly tested. The future collaboration is very likely due to the simulation skills of the UCLM group.
- JYFL-CERN: information exchange concerning the possibility of implementing light emission diagnostic to monitor ion source stability
- GANIL-LPSC-GSI: GSI ion source group has an important expertise in metallic ion beam production. The use of a thin Ta liner placed in the ECR ion source chamber is a current technique, which has been tested at GANIL for the production of Ca ion beam. Ca (and Ni) beams are expected to be the first heavy multi-charged ion beams of the GANIL/SPIRAL2 facility. To evaporate Ca atoms, a low temperature oven has been developed by LPSC laboratory at Grenoble, which reduces the thermal coupling between the oven and the plasma. The oven has been successfully tested and commissioned at LPSC. A long-term test is planned by 2020 on the heavy ion injector of the SPIRAL2 facility. The oven will be potentially adapted to other ion production installations.
- UCLM-JYFL: New experimental design with a multi-cusp magnetic confinement system.
- Exchange of equipment (UCLM): UCLM received a high voltage power supply from GSI to be used with the UCLM plasma generator. UCLM also received a set of high-power magnets to develop a new multi-cusp magnetic confinement for the plasma generator. The exchange of equipment was invaluable for UCLM to continue their research activities.
- GSI-LPSC: A joint GSI – LPSC experiment was carried out at LPSC on the PHOENIX ion source (early 2018). GSI team brought equipment enabling to inject a second variable microwave frequency into the plasma. The goal was to investigate the effect of double frequency plasma heating on the high charge state ion beam intensity and its stability. The results were analysed and presented at the ECRIS2018 conference organized at Catania, Italy.
- LPSC-UCLM: In early 2019, following the UCLM hands-on-training that took place in December 2018, LPSC ion sources group collaborated with UCLM on their ion source microwave coupling. During operation, the reflected power was found to be high with respect to the transmitted power. The actual coupling system was simulated with HFSS, including the vacuum window and the coupling flange. Some verification tests were proposed and an optimum configuration was calculated.
- The ATOMKI team has found the network activity very useful, especially the hands-on training. During the trainings, several good ideas and practical advices were received from the organizers. These were used and considered in the following research activities. For example, ATOMKI participation in the “Highly charged plasma diagnostics” and in the “Microwave-based techniques to improve the performances of the ECRISs” trainings inspired and helped ATOMKI team to carry out successful experiments finally published in Plasma Sources Sciences and Technology.

- the use of OES at GSI (in collaboration with JYFL) which has been initiated and stimulated by the corresponding hands-on-training at Jyväskylä. The measurements with the optical spectrometer were found to be very useful for ECRIS operation with metal elements like ^{48}Ca .

CONCLUSION

The program of MIDAS-NA and all related reports have successfully been completed. During the activity, 4 annual meetings and 15 hands-on training sessions were organized. It can be concluded that workshops and especially the hands-on training are a favourable tool to promote the networking and the transfer of the optimised and the most useful methods among the partners. On-site training proved to offer an inspiring environment for experts, young physicists and engineers to improve their expertise by the courses offered by the partner institutes. The feedback from the colleagues who participated in the hands-on training was very positive. Many fruitful discussions were stimulated leading to new ideas for improved methodology and techniques and consequently has stimulated new collaboration, development and research. The annual meetings have also played a crucial role in the successful planning and implementation of the MIDAS database and the hands-on training. The MIDAS database includes a vast amount of information needed for day-to-day operation of ECR ion sources. It also includes all documents related to the hands-on training and the annual meetings.